

FINAL REPORT

SR-27

Physical, chemical, biological and oceanographic  
factors relating to disposal of dredged material  
in Massachusetts Bay - Phase I.

Contract No. DACW33-73-C-0153

Submitted to:  
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Corps of Engineers  
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## ABSTRACT

Base line studies of water quality, hydrography, and benthic animal populations at the Boston Lightship Dumping Grounds were carried out without prejudice from July, 1973 to September, 1974. Earlier faunal studies by Verrill were not quantitative nor locale nor sediment specific, and thus could not be correlated. No effort was made to obtain specific hydrological data on Massachusetts Bay from M.I.T. or consulting corporations who have carried out or reported such studies and might prejudice this study. An unsuccessful effort was made to determine the history of dumping on the site. During the period of study, no dumping was authorized by the Corps of Engineers until September, 1974, and only private contractors might possibly have been dumping. Short dumpings scheduled for the Foul Grounds were believed to be observed in the Lightship Dumping Grounds but because of difficulty in pin pointing position, could not be verified.

Surface and mid-water currents were not categorized because they are weather dependent and the general trend is well known. Bottom current measurements covered only a one-month period and confirmed recent and "ancient" studies, i.e., the movement is steadily to the Southeast with a counter clock-wise movement correlated with Boston tides.

The water column above the site showed no specific differences in BOD, DO, COD, or salinity from that expected in non-polluted areas of similar depth in the Bay. Phosphates, Nitrites, and Calcium showed no peculiarities, but the Law of Mass Action which has not been considered in many studies demonstrated that the steady state did not involve extraneous additions or deletions.

The benthic fauna appeared to occupy all available living space.

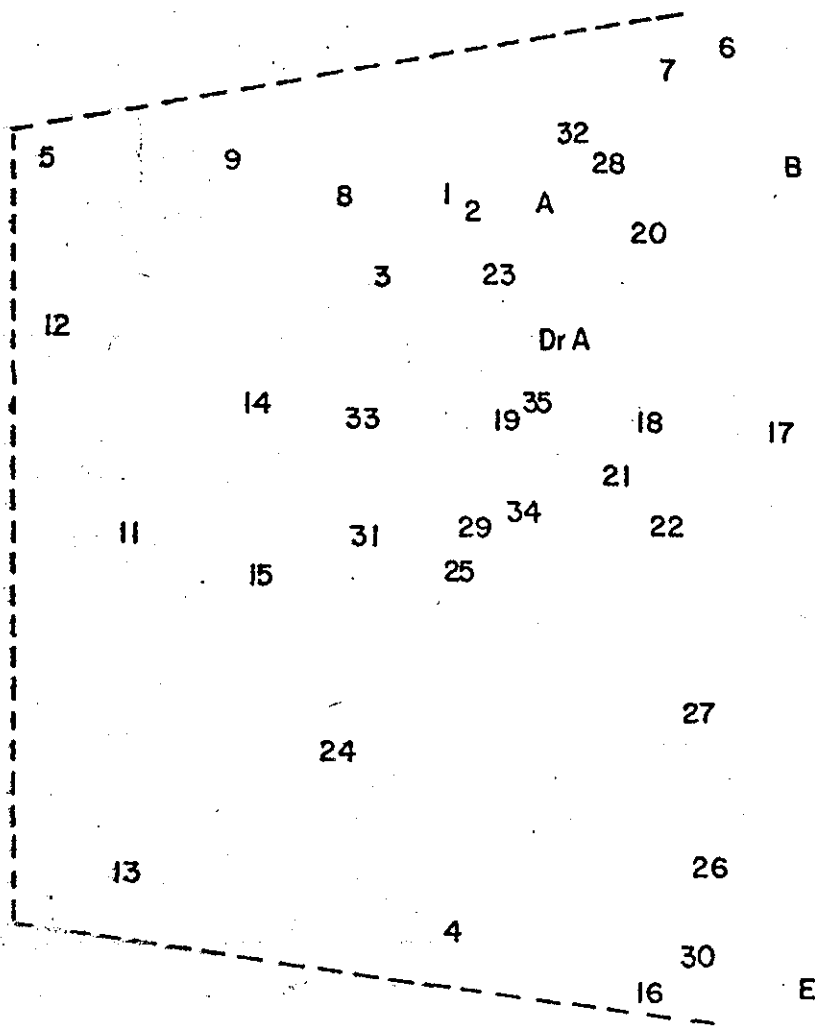
42°

—24

—22

—20

—18



APPROXIMATE STATION LOCATIONS

Early studies of the Bay gave no information as to population densities nor diversity, and thus opportunists vs. normal inhabitants could not be isolated. This would require follow-up studies after a period of dumping. Species diversity and abundance was high at all stations except for an area of bare hard green clay. The presence of a set of mahogany quahogs indicates the potential of the environment to support a population of commercially important species. The question of man-made vs. natural environment is not resolved by the data herein assembled.

The biomass of polychaets and pelecypods would indicate a high potential for feeding of bottom dwelling fin-fish. Young of such fin-fish were taken in this study. In any open sea or bay environment, the movement of fin-fish is a variable, and the failure to obtain species is not considered to be significant. [The absence of goldenrod pollen grains in an air sample taken by an airplane flying over Nebraska in July does not tell one anything about the presence of goldenrod (any species) there at the time.]

On the basis of these preliminary studies, it is concluded that wherever dumping has occurred on the Boston Lightship Dumping Grounds, there has been a repopulation. Further, the dumping may have stressed the existing benthic population, but no stress is apparent in the populations that have taken over. The biomass is large both in species and abundance. Whatever "desert" occurred following dumping (of dredge spoil?) no longer exists, and possibly (to be determined by future studies) physical factors have improved the environment for species diversity as well as species abundance.

## INTRODUCTION

Preliminary studies on the Boston Lightship Dumping Grounds were carried out over the period 24 July, 1973 thru 25 September, 1974. The area of the Dumping Grounds extends from  $70^{\circ}43'2''$  to  $70^{\circ}36'8''$ W. On the West side it lies between  $42^{\circ}18'7''$  and  $42^{\circ}23'1''$ N and flairs North and South so that the eastward edge lies between  $42^{\circ}24'$  and  $42^{\circ}18'3''$  North Latitude. The purpose of these studies was to obtain base-line information during a period in which the grounds were not being used for dumping.

In September, 1974, point dumping was authorized in a one-half mile radius around a buoy located at  $42^{\circ}21'14''$  North Latitude and  $70^{\circ}40'12''$  West Longitude. Permanent stations were then selected at a distance of approximately 200 meters from the edge of the circle at the SE, NE, NW, and SW corners. These stations will be used for monitoring.

## WATER QUALITY

Samples from the dumping ground were initially taken semi-weekly, however, statistical analysis of results showed that bi-weekly sampling (weather permitting) would yield the desired information for this first phase of the dumping ground study. Subsequent samples were taken less frequently.

No reference to tidal cycles was recorded but the time (E.D.T.) of sampling and the gross meteorological observation were noted. The phase of the tide can be obtained from "Tide Tables, East coast of North and South America".

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samples were analyzed for selected heavy metals, sulfides, and humic substances. A laboratory investigation of oxygen diffusion in seawater was also made.

Water samples were taken at the surface, at a location 1-3m above the bottom and at a point midway between the surface and the bottom. Mid-depth and bottom samples were taken in 'Nansen' bottles placed on a cable at depths determined from the ship's sonar depth guage. Depths recorded are cable length depths. Surface samples were obtained as grab samples taken just below the surface layer to minimize contamination from floating impurities. Temperatures were taken from readings of protected reversing thermometers. Sediment samples were taken with a 'Smith-McIntyre' grab and with a 'boomerang' corer.

Water samples were stored in D. O. bottles. The dissolved oxygen samples were immediately preserved with alkaline iodide and manganese II sulfate. Chemical Oxygen Demand samples were preserved one hour after sampling. Biological Oxygen Demand samples were analyzed 72 hours after sampling. All water samples were stored in the dark at 15°C. Sediment samples were stored in 'Whirlpaks' frozen until analyzed.

Salinity values were obtained from chlorinity titrations using a modified Knudsen titration procedure. Oxygen measurements were made using a modified Winkler titration. The Winkler modification used a nitrogen purge to deoxygenate the blanks. Nitrite corrections were not made on the oxygen results. Surface samples were not analyzed for dissolved oxygen since preliminary measurements showed these samples to be saturated. The dissolved oxygen was compared to the saturation value obtained from the tables by Murray and Riley<sup>1</sup>. The % Biological Oxygen Demand was calculated using actual

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<sup>1</sup>Murray and Riley Deep Sea Res. 10: 311 (1969)

content for midwater and bottom samples and using the saturation value for the surface sample.

Calcium ion content was determined on filtered samples using a photometric EGTA titration procedure. The calcium ratio was calculated as a measured value versus the expected value computed from the chlorinity using Marcets' principle.

Analysis of nutrients and trace constituents were made on filtered samples. The nutrients were determined spectrophotometrically, the trace metals were detected polarographically and by atomic absorption spectrometry. The nitrite was determined directly by a diazotization color development. The nitrate was determined by difference using a cadmium reductor prior to color development. Phosphate was determined by the molybdenum blue method.

Sediments were extracted with acid and the extract analyzed for selected heavy metals. Alkaline extracts of the sediments were measured spectrophotometrically for humic acid content.

Analyses were made in duplicate.

## RESULTS AND DISCUSSION

### Salinity and Temperature (Appendix 1, 2, 3):

As expected there was a seasonal variation in the temperature, the largest fluctuations were at the surface ( $3.5^{\circ}$  to  $19^{\circ}\text{C}$ ). Mid-depth and bottom water temperatures had smaller fluctuations ( $3.5^{\circ}$  to  $12^{\circ}\text{C}$  and  $3.9^{\circ}$  to  $9^{\circ}\text{C}$  respectively). The range of temperature with depth was very large in the early fall ( $10^{\circ}\text{C}$ ) and small in early spring ( $2^{\circ}\text{C}$ ). The salinity variations did not have appreciable seasonal dependence, however, at the surface large salinity fluctuations were measured (29.4% to 32.2%). These variations are due to evaporation and the influx of freshwater. At mid-depth and

at the bottom salinity variations were much smaller but above the error level of the analysis method. There is a positive correlation between salinity and depth ( $r = .72$ ).

The salinity and temperature measurements indicate the existence of a positive density gradient which is large in the late summer and fall and which is small in the late winter and spring; the presence of this gradient inhibits mixing and is probably one of the causes for low oxygen levels even in shallow water. The mixing that does occur is probably caused by currents and tidal flows. Measurements of temperature and salinity at the edge of the dumping ground and well outside of the dumping ground ( $70^{\circ} 45'W$ ,  $42^{\circ} 21'N$ ) showed no significant differences when compared to dumping ground measurements.

#### Oxygen and Biological Oxygen Demand:

The dissolved oxygen (Appendix 5) in the water did not differ significantly between mid-depth water and water taken 1 to 3 meters above the bottom; however, a few samples taken on the bottom containing sediment had lower levels of dissolved oxygen. Some seasonal variations of dissolved oxygen were noted in samples taken below the 20 meter level. Some of the dissolved oxygen variations are due to water temperature changes, but even after correcting the values for the decreased solubility of oxygen at higher temperatures there is still a seasonal variation. The dissolved oxygen values below 20m vary from 50 to 80% saturation in the spring and summer but drop to 40% saturation levels in the fall. Higher saturation values of dissolved oxygen were measured in locations outside the dumping ground; however, since only a few measurements were made outside the dumping ground, any conclusion based on this information needs further verification.

Chemical Oxygen Demand (COD) measurements were made on samples treated

with alkaline iodide and manganese II sulfate one hour after sampling. The values proved to be highly variable and far too large based on other information available. It is probable that Biological Oxygen Demand contributed to the values obtained. No conclusions were drawn from the COD measurements.

Biological Oxygen Demand (BOD) below the 20 meter level for clear water varied from 5 to 30% of the available oxygen. Since the available dissolved oxygen varies on a seasonal basis, the absolute BOD is also seasonally variable. Although mid-depth BOD values did not significantly differ from the BOD measurements on water taken 1 to 3 m above the bottom, water samples taken on the bottom with sediment showed a very high BOD. The sediments contain humic acids and probably other organic material that contribute to the high BOD. Surface water BOD parallel the measurements below 20m but at a much higher level, 25 to 55% of the saturation value. On an absolute basis this is even higher than the subsurface values which are based on lower levels of oxygen.

#### Calcium Ion:

Calcium is a conservative element in seawater. However, variations in the ratio of observed calcium to calculated calcium can be caused by an influx of calcium from external sources. High calcium ratios could be expected where there is a large river water input and where dumping of calcareous materials occur in conjunction with low pH values. Very few high ratios were observed, and within method error limits almost all ratios were unity (Appendix 6).

#### Nutrients:

Nitrite concentrations (Appendix 6) fluctuated widely (3 to 53 ppb). No seasonal, depth or location trends were observed. Inorganic phosphate concentrations were also highly variable (0 to 80 ppb) generally water

samples during winter and early spring months had higher phosphate levels (Appendix 6) than the rest of the year, however, the trend is not a strong one.

#### Trace metals in seawater:

Several seawater samples were semi-quantitatively analyzed for lead, zinc and mercury and were found not to exceed the expected values for unpolluted seawater.

#### Sediments:

Only preliminary semi-quantitative analyses were performed on a small number of samples, therefore any conclusions must be provisional. Humic acids and organic materials are present in greater than trace quantities. Heavy metal sulfides are present indicating anoxic conditions in some locations. Iron, copper and zinc are present in the sediments in trace amounts probably as sulfides.

## THE BENTHIC POPULATIONS

### Methods

Equipment for benthic sampling at the stations consisted of:

Smith-McIntyre Grab	-	Stations 10A, B, D, E.
Scallop Dredge	-	Station 10 DrA.
Higgins Epibenthic Sled	-	Station 1-10, 11-21, 26, 30, 32.
Van Veen Grab	-	Stations 21-26, 27-30, 31, 33-54.

Substrate was washed by running seawater and collected on 2., 1., and 0.33 mm. screens. During the summer months, the animals were anaesthetized and preserved in formalin aboard ship. In cooler weather, the specimens were kept on a running seawater table in the laboratory prior to a cursory sorting and then anaesthetized and preserved. Sorting and counting was done under a binocular dissecting microscope. The number of individuals of each species was recorded. While the Van Veen Grab has proved to be reliable and efficient on soft bottoms and some statistical weight can be given to results obtained from three samples from a station (recommendation of the Baltic Marine Biologists 1973) too many variables are present for dogmatic interpretations of results. In the results, some figures of density per  $0.1\text{m}^2$  are given, but these are only considered indicative. Densities in the faunal list are indicated: -

- present
- . common - ( 17-100)
- .. abundant- (100-500)
- ... very large numbers that mask the remainder of the sample. (over 500)

### Results

Dumping ground substrate varies randomly. There is a central area (see map) of rock-hard green clay which could not be sampled with a grab and which only yielded loose fragments of clay and a few rocks with the Higgins epibenthic sled. Fragments of the clay showed borings, but the animals

that produced the holes were not recovered. The rocks were well populated by barnacles (Balanus balanus), brachiopods (Terebratulina septentrionalis), polychaets (Hydroides uncinata, Spirorbis sp.) and ectoprocts.

A number of dead Littorina littorea were present at station 31 indicating a dumping of material dredged in shallower water. Fresh eel grass (Zostera sp.) was encountered at Station 20 possibly indicative of recent dumping near the station, but the population on station was indicative of a stable population.

Fin fishes, lobsters, and crabs were not obtained in the four efforts with an otter trawl made at different times of the year. On 5 September, 1974, two two-inch flounder and one three-inch hake (Merlucius sp.) were obtained in the Higgins epibenthic sled at station 30 at the SE corner of the grounds. No effort was made to sample for fish in the water column since the fish population in the Bay was not uniform and an absence of fish would not be indicative of anything concrete. The zooplankton throughout the study was comparable to that of the same day taken approximately 200 yards off East Point, Nahant, except that callanoid copepods were always more abundant in samples from the dumping ground, and cladocerans (Evadne and Podon) less abundant.

In general, the substrates can be characterized by dominant species -

silt-clay - Spio filicornis, Maldane sarsi

sand-gravel - Prionospio malmgreni

rocky - Ophiopholus aculeata, Ophiura robusti

Forty-eight percent of the non-sessile organisms at station 5 consisted of Ophiura robusta. Eighty-four percent of the non-sessiles at station 27 consisted of Spio filicornis (1100 per  $0.1M^2$ ) but eighty-eight percent at station 32 were Maldane sarsi (1050 per  $0.1M^2$ ). Only at the sandy station 30

did epibenthic organisms predominate, i.e., the amphipod Corophium crassicornis (1340 per  $0.1M^2$ ) and the cumacean Diastylus quadrosinosa (144 per  $0.1M^2$ ).

Species diversity ranged from a low of fourteen at station 15 to a high of eighty-two at station 3. The species recovered from station 15 indicate a failure of the gear since twenty-seven percent were Prionospio malmgreni and forty-two percent were Spio filicornis but large numbers of Nephtys were present and only one specimen of molluscs, Nassarius trivittatus was in the sample. This sample might have been on the clay-sand interface but was characterized as clay. No nematodes were present in the samples from stations 4 or 15, but station 4 was primarily rocky. Stations 10A, Dr A, 14, 16, and 29 had a very characteristic mud fauna - the mud starfish Ctenodiscus crispatus, the polychaet Sternaspis scutata, and the aplousobranch Chaetoderma nitidulum. One specimen of the latter species also occurred at station 1. Oddly, the mud dwelling sea cucumber Caudina arenata was only taken at station Dr A and only one specimen there. This was the only station sampled with a scallop dredge. Station 10A yielded the only specimen of the mud-silt polychaet Sphaerodoridium minutum, and the solitary ascidian Bostriobrachius pilularis was only taken at stations 23 and 27 and in neither situation was it abundant. The discovery of only a single specimen of Cerianthus americanus is also difficult to understand as is the occurrence of only one specimen of Dentalium sp. at each of three stations.

At station 25, the pelecypod Nucula tenuis had a density of 167 per  $0.1M^2$  and Thyasira gouldi 171 per  $0.1M^2$ . The highest incidence of the polychaet Spio filicornis also occurred at this station, i.e., 2,350 per  $0.1M^2$ .

Station 25 is about 200 meters from the SE edge of the area in which dumping began in September 1974. It had the highest population density of any station which was sampled, i.e., 2,916 macro-organisms exclusive of nematodes

per  $0.1\text{M}^2$ . Forty-four species of macro-animals were encountered. Stations 29 and 34 in the same general area had much lower densities and diversity, but Spio filicornis, Nucula tenuis, and Thyasira gouldi predominated as at station 25. The substrate throughout the three stations was basically similar (see sediment analysis for station 29) and appeared to form a belt extending eastward from stations 14 and 15 to the edge of the dumping grounds. The hard clay bottom extends South of this belt to a line between stations 24 and 27. Young mahogany quahogs, Arctica islandica occurred in the triangle between stations 24, 26, and 27; however, the area was not sampled with a scallop dredge for adults. At station 27 the population density of young Arctica islandica was 43 per  $0.1\text{M}^2$ .

Neither physical nor biological stress was indicated in any of the communities with the possible exceptions of 10B and 15. Species diversity at both stations was low, 14 species and less than 100 animals were obtained. Station 10B was characterized as a gravel substrate, but over 30 percent of the animals were polychaets, Prionospio malmgreni. At station 15, the substrate was clay and Spio filicornis constituted 27% of the animals which were recovered. In both cases, it would appear that there was a failure of the collecting gear. Thus, while these samples might possibly indicate a stressed community, the indicator species favor gear failure.

Physical stress probably holds for the hard clay area, but in the absence of adequate sampling methods this can only be assumed.

Species diversity and species abundance as indicated by repeat sampling at the monitoring stations (29 and 34, 19 and 35, 33 and 36, 31 and 37) show considerable variation. Fifty-six species were encountered at station 19, and thirty-nine at station 35, but in both cases, Spio filicornis accounted for about 50 percent of the animals present, with the pelecypod,

Nucula tenuis constituting about 10 percent. It is regrettable that vessel location and bottom sampled cannot be more accurately pin-pointed. Stations are designated by vessel location at the moment of sampling. Wire inclination was not calculated for stations prior to station 29.

## CURRENT STUDIES

One EG&G Model 102 in-situ current meter was deployed from July 12 to August 14, 1974 in the Dumping Ground, Massachusetts Bay. The current meter was positioned on the mooring to record currents four feet off the bottom.

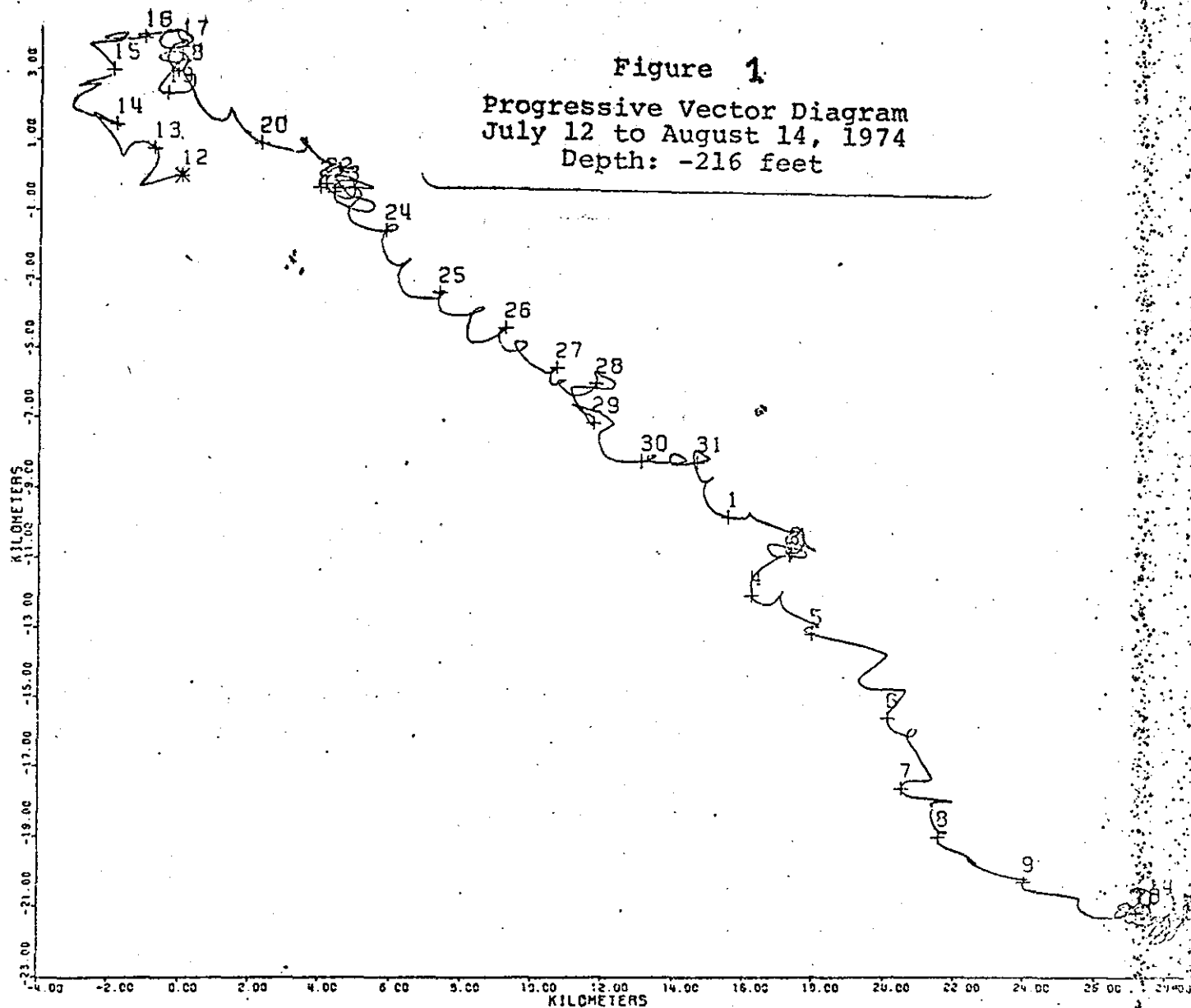
Bottom currents at the Dumping Ground are variable in regard to speed and direction. In general, velocities are low. The mode of the current speed is about 0.1 knots, but currents were recorded up to 0.4 knots.

The Lissplog of current speed and direction in time (in Appendix) indicates that currents vary with the tide, being weakest at times of high and low tides at Boston. The Lissplog also shows that current direction is not of the simple reversing type. However, the general trend of flow is away from Boston after high tide and toward Boston after low tide. A counter-clockwise rotary tide is the most common type of flow.

As can be seen on the polar coordinate histogram of direction (Figure the most prevalent directions of tide were to the southeast and northwest, but tides were recorded in every direction. The plot of rotor speed versus direction shows essentially the same result, with the greatest cluster of points in the southeast direction ( $120^{\circ}$ ).

The progressive vector diagram (Figure indicates that the general trend of advective flow was to the southeast during the period of the deployment.

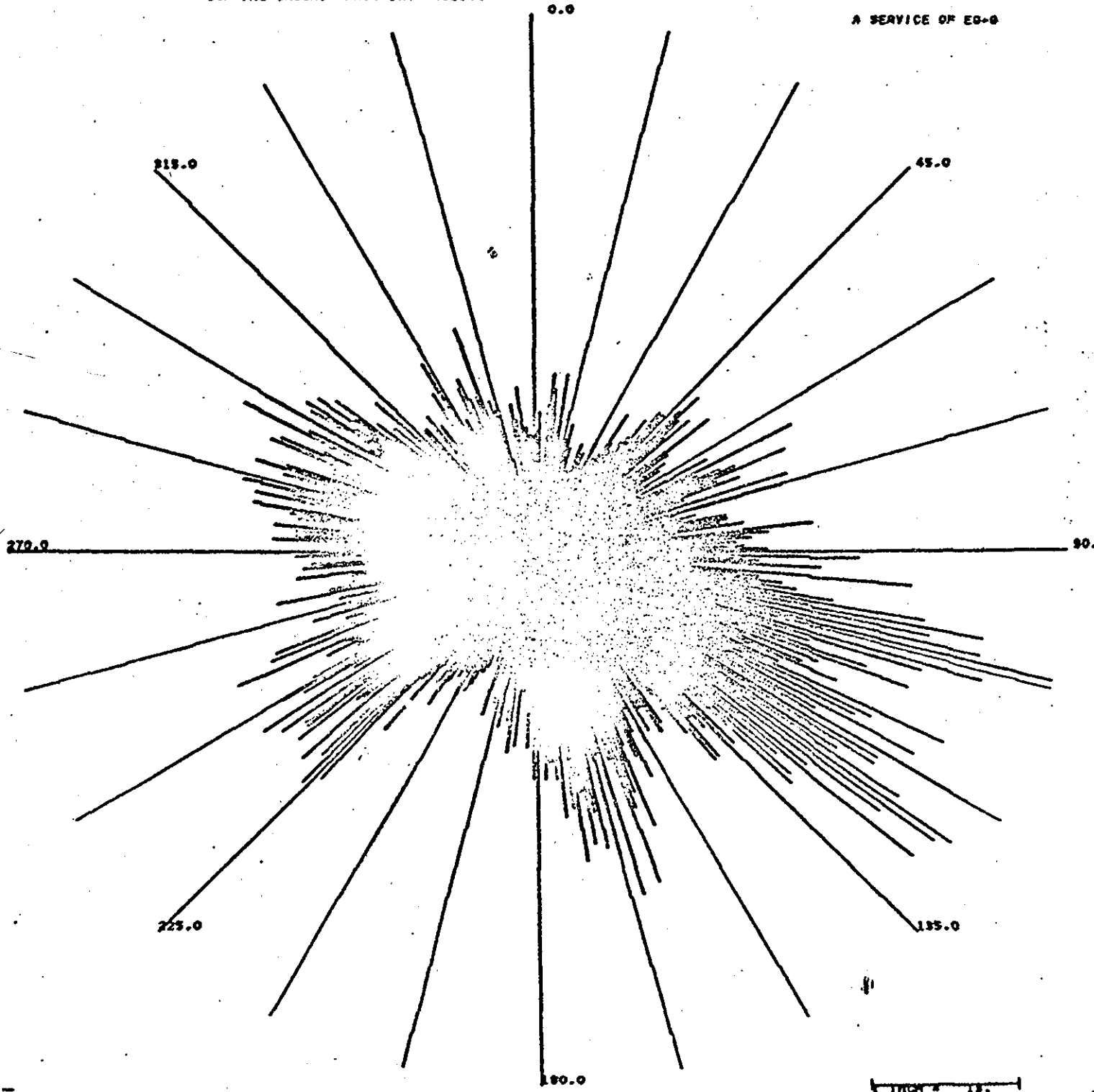
Figure 1.  
Progressive Vector Diagram  
July 12 to August 14, 1974  
Depth: -216 feet



7/12/74 TO 8/14/74

Figure 2  
July 12 to August 14, 1974  
Depth: -216 feet

DUMPING GROUND MASS BAY 402588 POLAR COORDINATE HISTOGRAM PLOT OF DIRECTION  
A SERVICE OF EG-6



## GRANULOMETRY

Granulometric analyses were carried out on three stations, #28, #29, and #31. These samples were all taken from the van Veen grab. Follow-up analyses at the monitoring stations are being made with a "boomerang" corer. The percent organics is deemed to be low and the silt is probably also low because of the shock wave produced by the van Veen grab.

SEDIMENTS PERCENT of Total Composition Excluding Granules and Up.

Grain	Diameter	#28	#29	#31
2.0 mm	Very Coarse Sand	0.418		0.36
1.0	" " "	0.136	0.239	1.20
0.5	Coarse Sand	0.405	0.590	6.03
0.25	Medium Sand	1.635	2.510	23.60
0.177	Fine Sand	1.778	4.840	17.90
0.125	" "	2.310	8.285	15.25
0.088	Very Fine Sand	2.950	29.150	11.60
0.063	Silt	5.500	17.150	5.77
0.044 (	From #29 on:	3.250		
0.037 (	.063 → .0312	0.583	14.300	6.90
0.0312 ( For	.0312 → .0156	13.320	8.140	5.06
0.0156 ( #28	.0156 → .0078	15.510	6.490	3.16
0.0078 ( only	.0078 → .0039	14.400	2.898	1.07
0.0039 (	↓ <.0039 Clay	5.430	5.680	2.10
0.0039 >	Clay	32.400		
<u>Total Percentages</u>				
% Sand		9.632	45.614	75.94
% Silt		57.993	48.978	21.96
% Clay		32.400	5.680	2.10

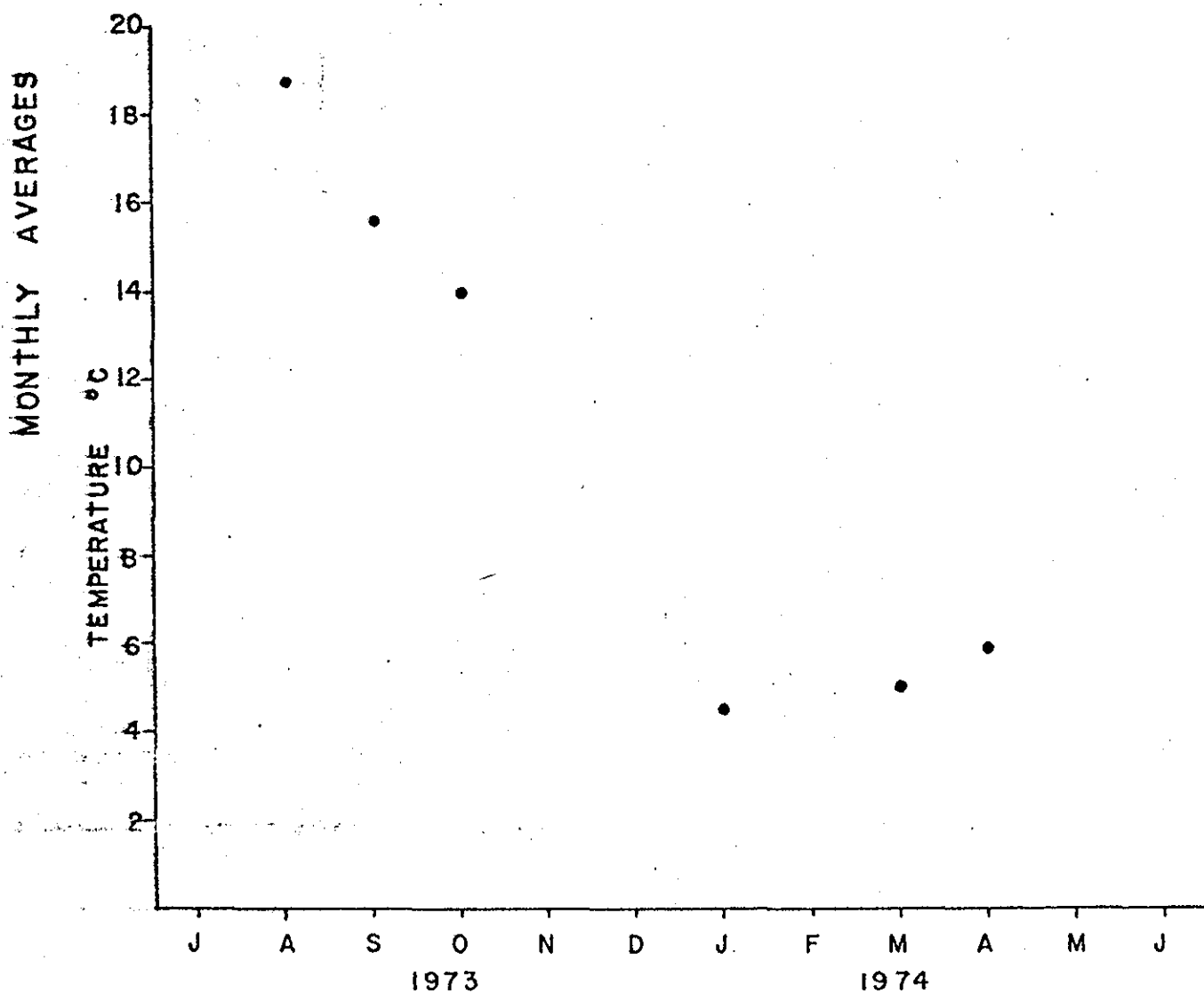
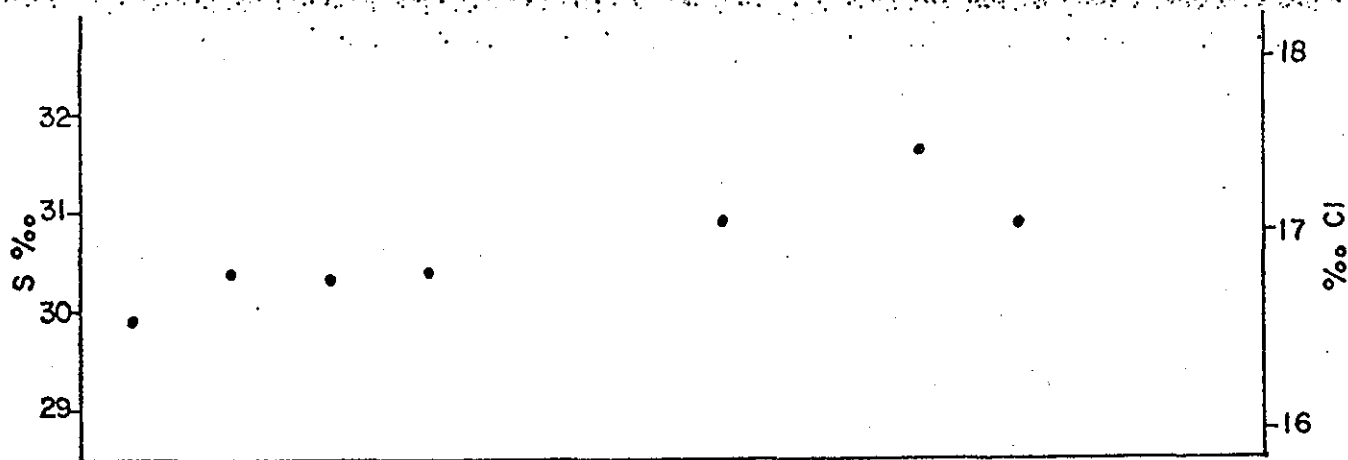
Number of Larger Grains

Cobble (64 → 256 mm)	-	2	
Pebble (4 → 64 mm)	36	56	Few
Granule (2 4 mm)	Many	Many	Many

Organics Percent

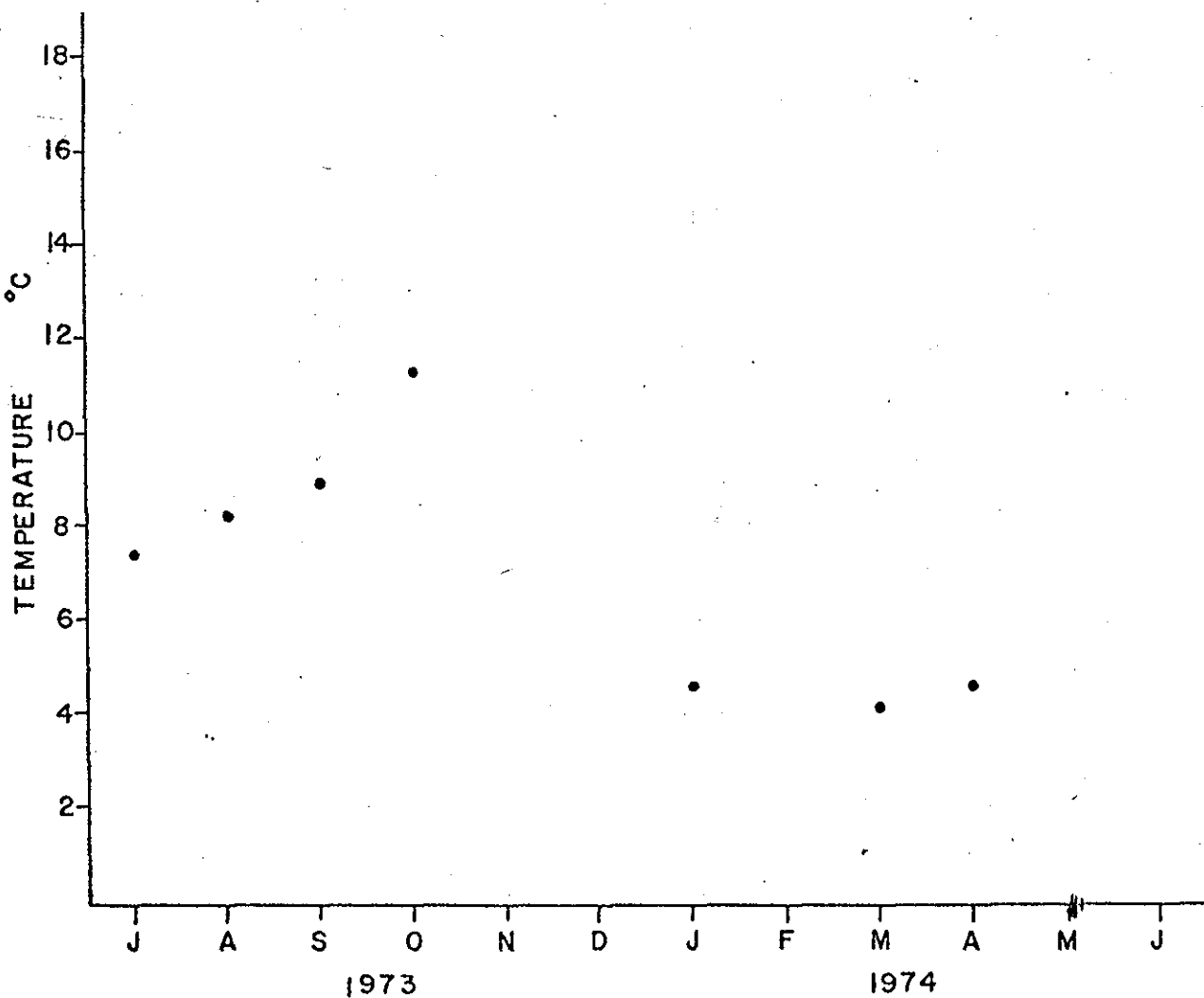
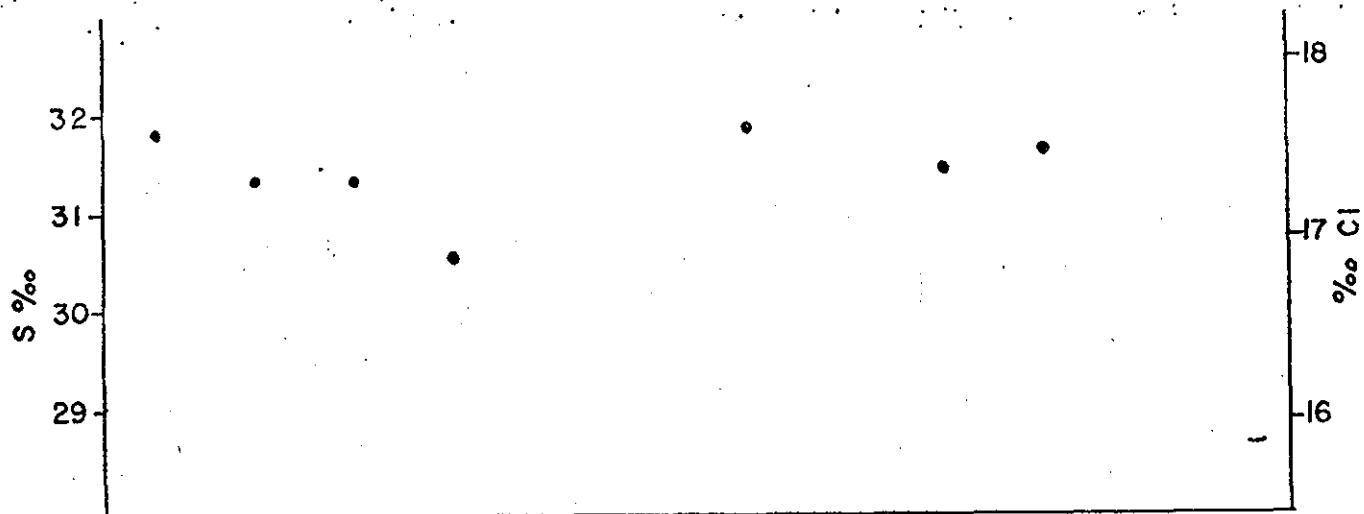
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APPENDIX



SALINITY AND TEMPERATURE  
SURFACE WATER

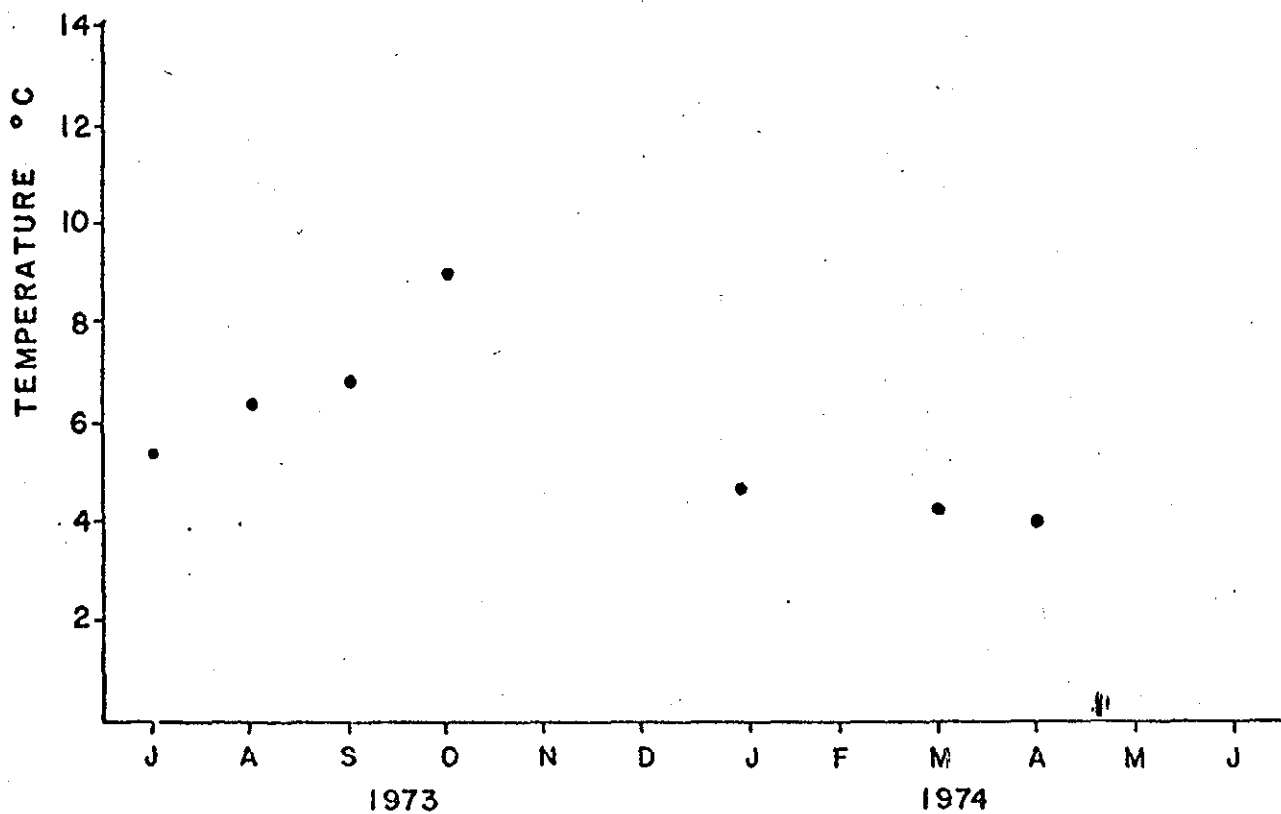
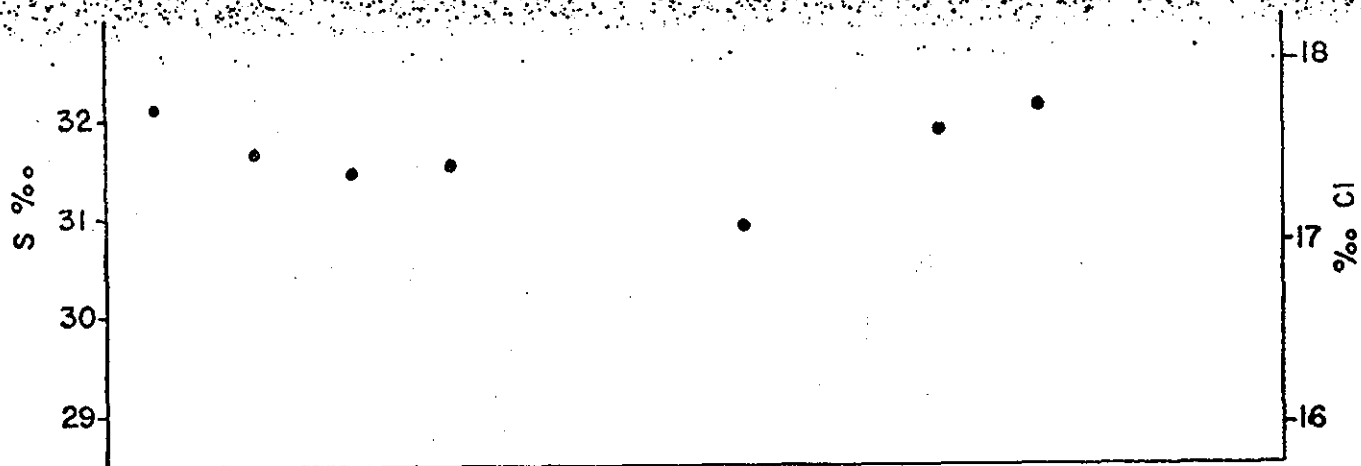
MONTHLY AVERAGES



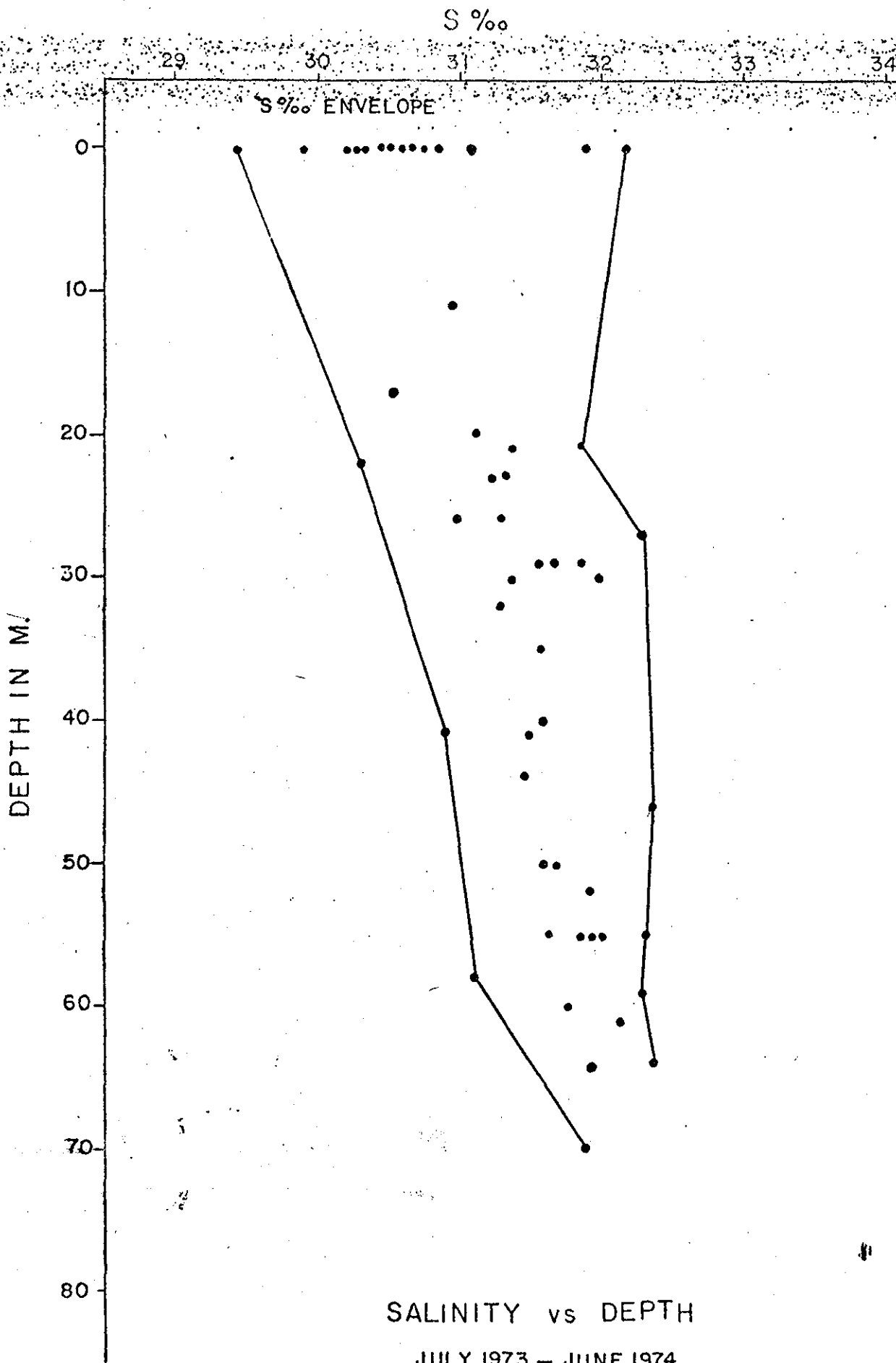
SALINITY AND TEMPERATURE

MIDWATER (17-29M)

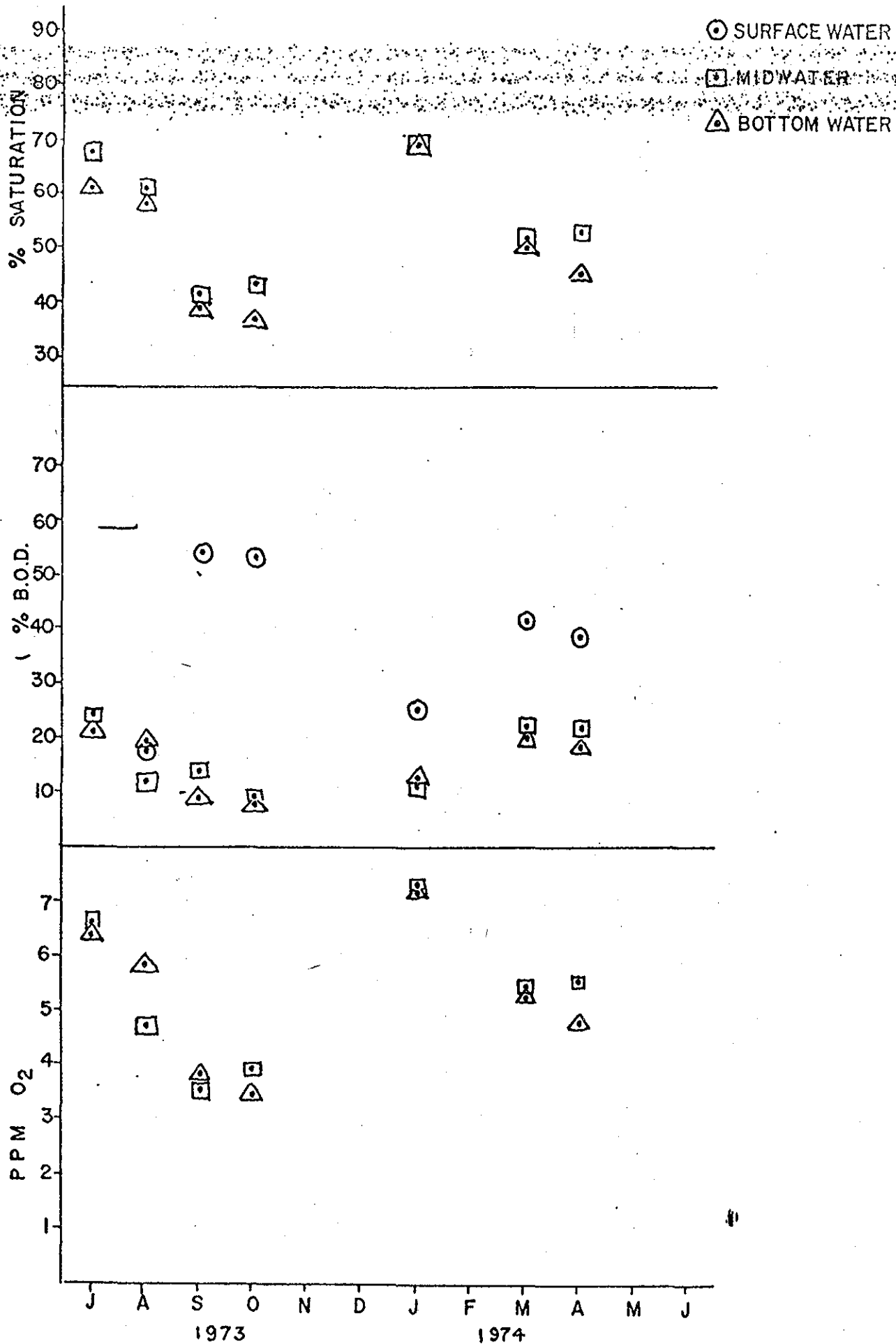
MONTHLY AVERAGES



SALINITY AND TEMPERATURE  
BOTTOM WATER (35-68 M)



MONTHLY AVERAGES

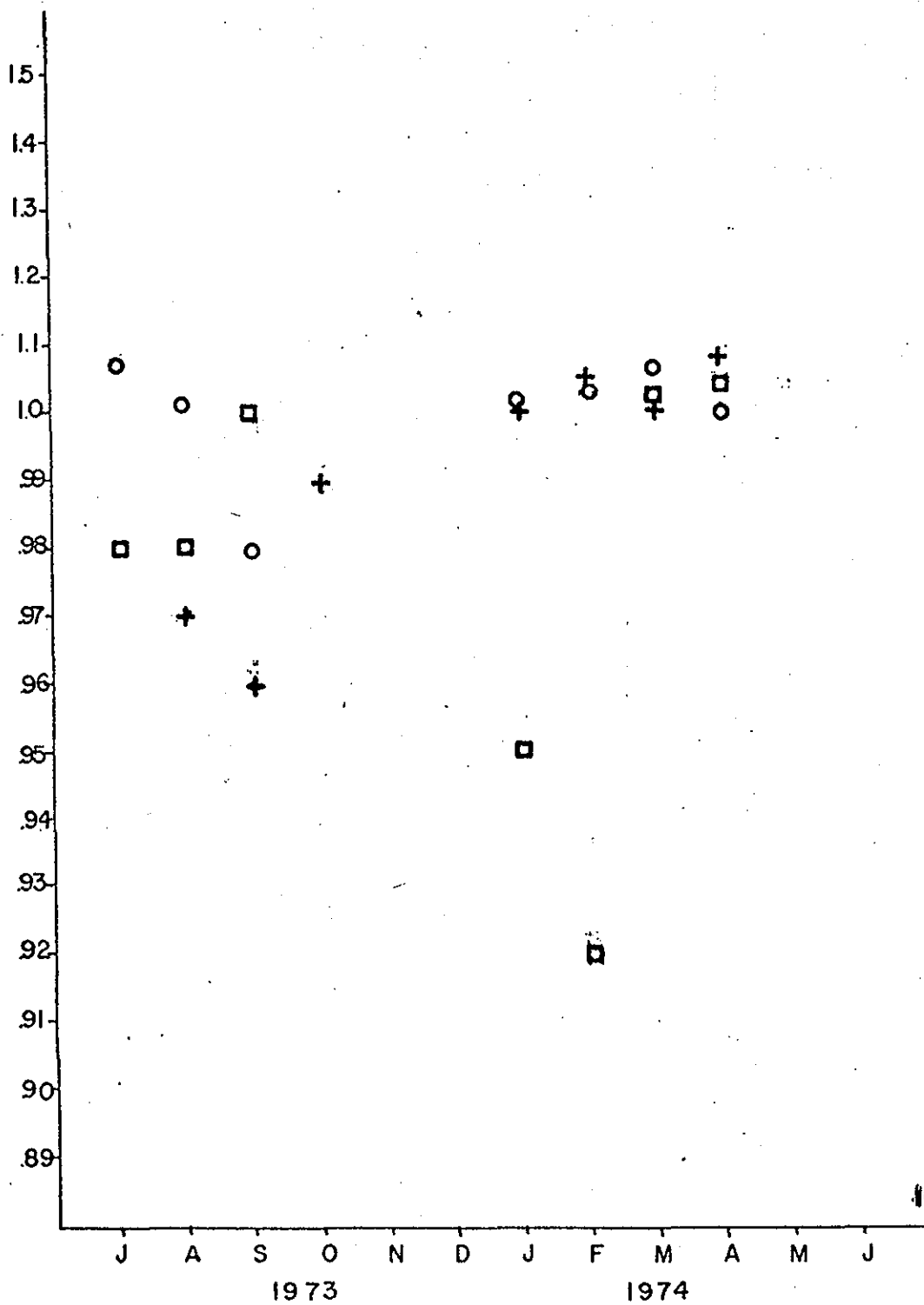


OXYGEN CONTENT OF DUMPING GROUND WATER

○ SURFACE WATER  
 □ MID WATER  
 + BOTTOM WATER

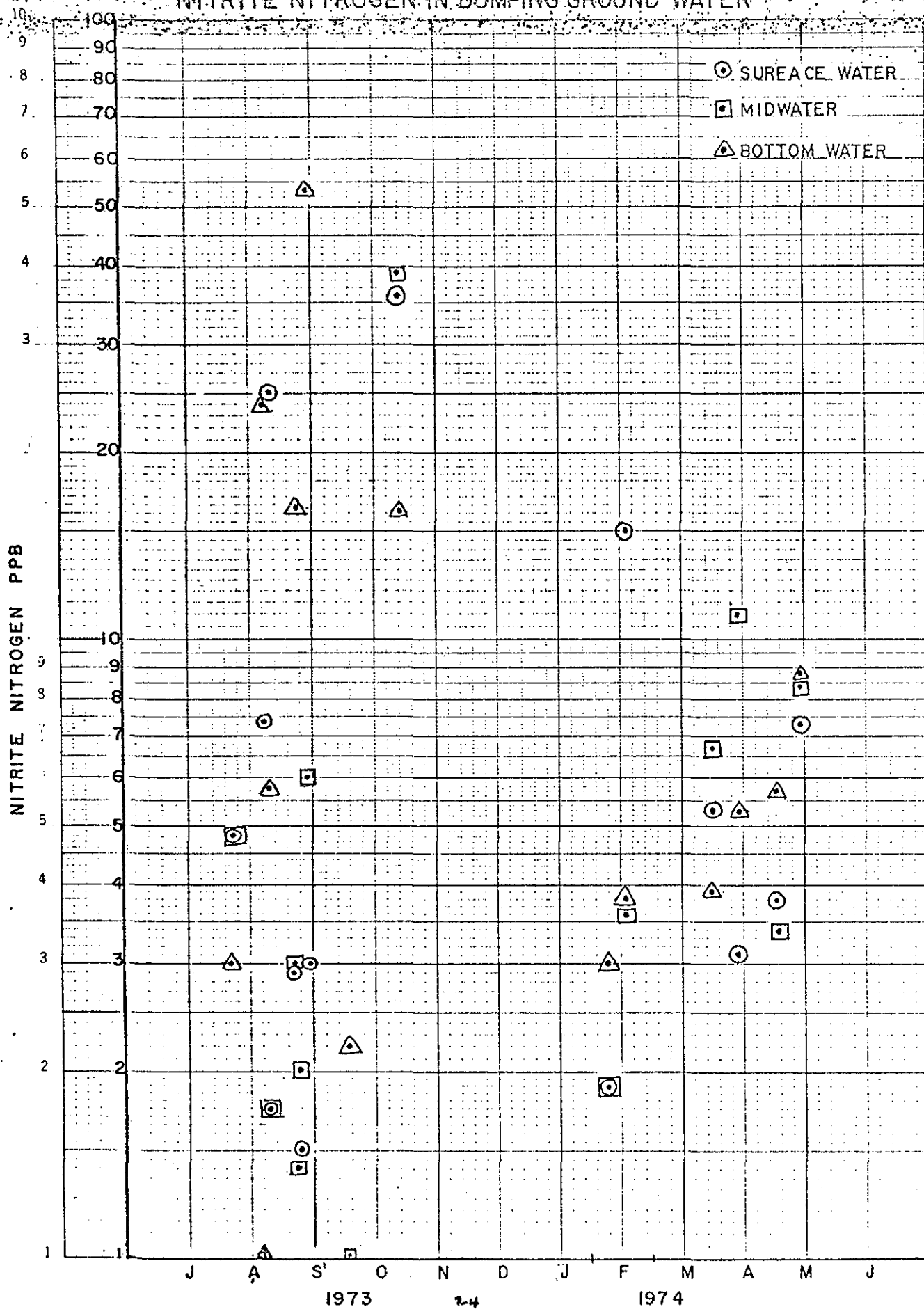
MONTHLY AVERAGES

RATIO Ca FOUND / Ca EXPECTED

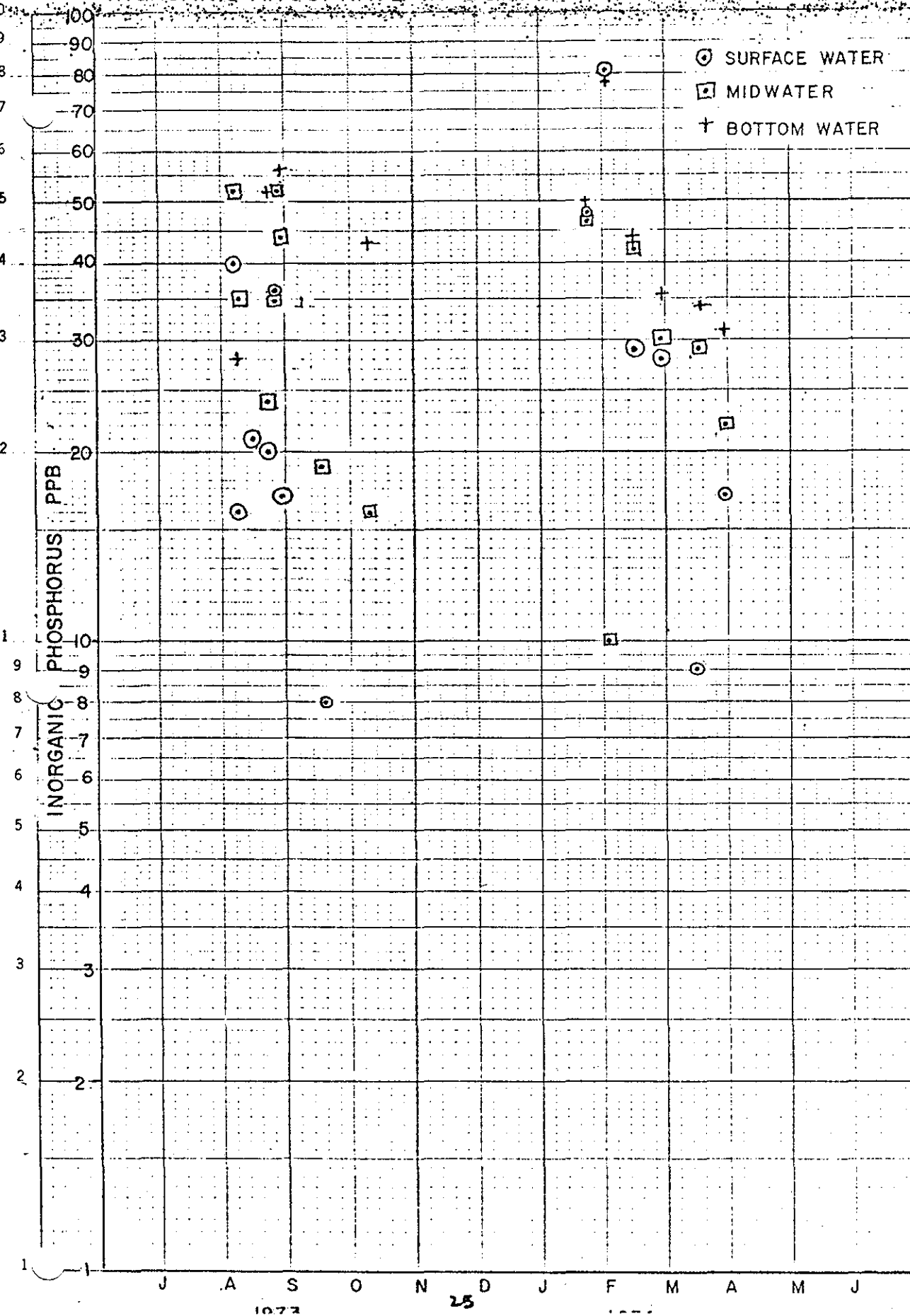


CALCIUM IONS IN DUMPING GROUND WATER

# NITRITE NITROGEN IN DUMPING GROUND WATER



# INORGANIC PHOSPHATE IN DUMPING GROUND WATER



## APPENDIX XI

- present  
  . common (17-100)  
  .. abundant (100-500)  
  ... over 500  
      (meiofauna not included)

## SEA WATER ANALYSIS

DEPTH M	TEMP °C	S <sup>o</sup> /oo	D.O. PPM	SATURTN. %	B.O.D. %	Ca Mx10 <sup>3</sup>	Ca RATIO	NO <sub>2</sub> N PPB	INORG P PPB
7/24/73	70°39'W, 42°23'N								
0		29.90						4.8	
29	7.2	31.84	6.66	68.2	24.2	10.3	1.07	4.8	
61	5.4	32.10	6.39	61.7	22.1	9.5	.98	3.0	
8/7/73	70°40'W, 42°23'N								
0	19.8	30.47			16.3				
23	7.3	31.30	5.69	58.1		9.3	.99	7.4	40
44	6.5	31.54	6.95	69.6		9.0	.95	24.0	52
8/9/73	70°40'W, 42°23'N								
0	18.8	30.26			25.7	8.7	.96	1.8	16
26	9.6	31.27	4.54	48.7	8.4	8.7	.92	1.8	36
55	6.2	31.91	5.21	51.9	28.4	9.2	.96	.7	28
8/16/73	70°40'W, 42°22.5'N								
0	17.9	30.47			16.2	9.0	.98	25.0	21
52	6.2	31.88	5.84	58.2	27.6	8.8	.92	5.9	15
8/21/73	70°40'W, 42°19'N (Station 4)								
0	18.5	30.68			6.2	9.0	.97	46.0	15
14	12.5	30.87	7.18	81.9	10.7	9.4	1.01	1.7	22
27	7.1	31.24	5.78	58.8	5.7	7.6	.81	.3	58
8/21/73									
0	19.0	30.29			6.5	10.2	1.11	2.9	20
26	10.1	30.99	7.33	79.4	7.5	9.4	1.01	1.4	24
50	6.4	31.60	5.88	58.8	1.4	9.5	1.00	3.0	52
8/23/73	70°40'W, 42°19'N								
0	18.1	30.29			11.6	9.1	1.00	1.5	36
29	7.2	31.67	5.68	58.1	12.1	9.1	.96	2.1	51
58	6.1	31.11	5.40	53.5	10.2	9.5	1.02	16.3	36
8/23/73	70°45'W, 42°21'N								
0	17.5	30.60			13.2	9.2	1.00	1.2	11
12	16.5	30.95	6.28	78.0	19.2	8.2	.88	26.0	19
27	7.3	31.51	5.57	57.0	11.5	9.5	1.00	34.7	38
8/27/73	70°35'W, 42°35'N								
0	18.4	30.50			19.6	9.0	.98	3.0	17
29	7.9	31.56	5.80	60.1	15.5	9.8	1.03	6.0	44
55	6.7	31.85	5.72	57.6	12.2	9.6	1.00	53.0	56
9/11/73	70°39.5'W, 42°23'N								
0	17.0	29.41			51.9	8.9	1.01	1.3	1
11	7.3	30.91	4.04	41.2	10.8	9.2	.99	1.2	28
22	6.1	30.29	3.94	38.8	12.0	9.4	1.03	4.9	34

## SEA WATER ANALYSIS (Cont.)

DEPTH M	TEMP °C	Sal/66	D.O. PPM	SATURTN. %	B.O.D. %	Ca Mx10 <sup>3</sup>	Ca RATIO	NO <sub>2</sub> N PPB	INORG P PPB
9/18/73 70°41'W, 42°21'N									
0	15.5	30.24			54.3	8.9	.98	0.6	8
21	8.9	31.36	3.50	37.0	10.4	9.4	1.00	2.2	19
41	6.8	31.47	3.85	38.8	9.8	9.1	.96	0.2	
10/12/73 70°43.5'W, 42°19'N (Near Station 13)									
0	13.9	30.33			53.1	7.6	.83	36.0	0
17	11.3	30.54	3.89	43.3	8.3	6.3	.68	39.0	16
35	9.0	31.56	3.49	37.0	8.0	9.4	.99	16.0	43
1/24/74 70°41'W, 42°24'N									
0	4.5	30.82			25.1	9.3	1.00	1.9	48
21	4.6	31.84	7.25	69.4	11.6	9.1	.95	1.9	47
41	4.7	30.89	7.26	69.3	12.5	9.3	1.00	3.0	49
3/2/74 70°40'W, 42°23'N									
0	3.5	30.77			45.4	9.4	1.01	15.0	81
23	3.6	31.21	5.39	50.2	21.7	8.2	.87	3.6	10
46	4.5	32.34	5.05	48.4	18.4	10.0	1.02	3.8	80
3/15/74									
0	4.2	31.88			41.9	10.1	1.05	5.3	29
	4.1	30.90				9.7	1.04	6.7	42
	4.3	31.07				9.9	1.03	3.9	44
3/28/74 70°41'W, 42°22'N									
0	7.4	32.16			37.9	9.9	1.02	3.1	28
27	4.3	32.28	5.58	53.2	22.4	9.8	1.01	11.0	30
55	3.9	32.27	5.57	52.6	24.6	10.0	1.03	5.3	35
4/18/74 70°39.5'W, 42°21'N									
0	5.8	30.64			37.2	9.6	1.04	3.7	9
30	4.0	31.97	5.49	51.9	21.5	9.9	1.03	3.4	29
59	4.0	32.04	4.73	44.7	17.3	10.0	1.03	5.7	34
4/18/74 70°39'W, 42°23'N									
0	5.8	30.57			41.7	9.6	1.05	4.4	29
35	4.0	31.89	5.46	51.6	22.7	9.7	1.02	4.7	22
70	4.0	31.86	4.84	45.7	22.5	10.4	1.09	3.0	47
4/26/74									
0	6.0	31.06			40.6	9.5	1.01	7.3	17
32	5.1	31.28	5.67	54.9	22.6	9.7	1.03	8.4	22
64	4.0	32.36	4.88	46.2	20.1	10.8	1.04	8.8	31

## SEA WATER ANALYSIS (Cont.)

DEPTH M	TEMP °C	S <sup>o</sup> /‰	D.O. PPM	SATURTN. %	B.O.D. %	Ca Mx10 <sup>3</sup>	Ca RATIO	NO <sub>2</sub> N PPB	INORG P PPB
8/1/74	70°38.9'W, 42°23'N			Station 28					
0	19.7	31.30	5.43	74.6	39.1			10.4	1 6
37	7.5	31.94	5.77	62.0	48.4			6.2	1 7
73	6.2	32.10	5.14	53.6	55.7			6.4	2 6
8/27/74	70°38.9'W, 42°23'N								
30	7.4	31.94	3.13	33.6	62.6			3.7	1 5
61	6.9	31.84	2.03	22.5	64.8			3.7	1 3
9/11/74	70°38'W, 42°23'N								
0	18.0	31.22	5.62	59.9	38.5			4.4	0 4
29	10.1	31.91	5.05	34.2	28.9			10.0	1 5
59	7.2	31.64	4.8	51.3	58.8			5.9	1 5

# QUALITATIVE SAMPLING

(Epibenthic Sled)

<u>Station #</u>	<u>Bottom Type</u>	<u>Date</u>	<u>Latitude</u>	<u>Longitude</u>	<u>Depth in Ft.</u>	<u>Noted Animals</u>	<u>No. Species</u>
1	sand	8/ 7/73	42°22'50"	70°40'00"	110	118	29
2	sand, rocks	8/19/73	42°22'50"	70°39'70"	180	121	32
3	clay-silt, rocks	8/16/73	42°22'30"	70°40'43"	170	677	82
4	rocks	8/21/73	42°19'00"	70°40'10"	170	177	26
5	rocks	9/ 6/73	42°22'90"	70°42'95"	160	267	39
6	rocks	9/ 8/73	42°23'63"	70°37'85"	210	451	49
7	silt-mud, rocks	9/ 9/73	42°23'55"	70°38'23"	225	186	29
8	silt-mud, rocks	9/ 9/73	42°23'00"	70°40'60"	130	82	26
9	rocks, gravel	9/ 9/73	42°23'18"	70°41'45"	155	194	37
11	rocks	9/17/73	42°21'00"	70°42'50"	133	255	60
12	mud, rocks	10/12/73	42°22'00"	70°42'80"	160	294	55
13	gravel	10/12/73	42°19'00"	70°42'30"	120	628	74
14	clay	10/13/73	42°21'20"	70°41'00"	170	1035	63
15	clay	10/13/73	42°20'65"	70°41'10"	170	73	14
16	mud	10/13/73	42°18'50"	70°38'60"	175	1241	68
17	mud	4/12/74	42°22'00"	70°37'00"	210	1018	49
18	mud	4/19/74	42°22'30"	70°39'50"	220	2685	39
19	mud	4/27/74	42°22'00"	70°39'70"	210	1019	56
20	gravel	5/ 4/74	42°22'70"	70°38'40"	240	829	50
23	rocks	5/29/74	42°22'50"	70°39'40"	210	2029	158
24	clay	6/ 2/74	42°19'70"	70°41'00"	155	1554	36
26	mud	6/19/74	42°19'00"	70°38'25"	170	2196	52
30	sand	9/ 5/74	42°19'40"	70°38'80"	165	1766	55
32	silt clay	9/ 9/74	42°22'70"	70°38'80"	200	1190	90

Station #	Bottom Type	Date	Latitude	Longitude	Depth In Ft.	Noted Animals	No. Species
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(Scallop Dredge)

10 DrA	silt-rocks	9/10/73	42°23'10"	70°39'50"	146	432	40
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QUANTITATIVE SAMPLING

(Smith McIntyre Grab)

10A	silt, sand	9/10/73	42°23'10"	70°39'50"	234	159	36
10B	gravel	9/10/73	42°23'00"	70°37'70"	242	35	14
10C	hard clay	9/10/73	42°20'00"	70°40'00"	265	no sample	
10D	silt, rocks	9/10/73	42°19'80"	70°37'10"	215	196	29
10E	silt, gravel	9/10/73	42°18'40"	70°37'60"	188	388	36

(van Veen Grab)

21	mud	5/14/74	42°21'50"	70°38'80"	220	474	37
22	mud	5/20/74	42°21'10"	70°38'90"	220	1241	48
25	mud	6/ 8/74	42°20'80"	70°41'00"	190	2916	52
27	clay	6/23/74	42°20'00"	70°38'70"	140	1304	34
28	mud, clay	8/ 1/74	42°23'00"	70°38'90"	240	335	20
29	mud, clay	8/27/74	42°21'30"	70°38'80"	205	652	36
31	sand	9/ 9/74	42°21'25"	70°40'60"	175	1022	24
33	silt, clay	9/25/74	42°21'90"	70°40'50"	200	228	25
34	silt, clay	9/25/74	42°21'30"	70°39'65"	200	289	25

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	
PORIFERA																																				
<u>Polymastia robusta</u>				-								-																								
<u>Suberterechinus hispidus</u>						.																														
<u>Iophon nigricans</u> (on <u>Terebratulina</u> )	-	-		-	-	-		-				-											-													
CNIDARIA																																				
<u>Cerianthus americanus</u>										-																										
<u>Edwardsia</u> sp.											-			-									-			-					-					
<u>Edwardsia elegans</u>																						-														
<u>Tealia felina</u>																	-																			
<u>Sertularella</u>												-	-																							
<u>Perigoniscus</u> (on <u>Colus</u> shell)			-																												-					
Family Hydractinidae sp.			-																																	
PLATYHELMINTHES																																				
<u>Discocelides ellipsoides</u>																	-																			
NEMERTEA																																				
<u>Amphiporus pulcher</u>				-								-	-															-								
<u>Cerebratulus luridus</u>																																				
<u>Cerebratulus marginatus</u> (?)																-																				
<u>Micrura afinis</u>				-		-	-					-	-	-		-				-	-															
<u>Micrura</u> sp. (pink)																						-	-			-										
<u>Lineus "dubius"</u> (w/o eyes)																													-			-				
<u>Micrura leidyi</u> (?)																														-						
Hoplonemertean sp.																														-						
<u>Micrura albida</u>																															-					
<u>Amphiporus</u> sp.																															-					
Palaeonemertean sp.																															-					
SIPUNCULIDA																																				
<u>Phascolion strombi</u>	-	-	-		-		-	-				-		-		-				-	-		-		-	-	-	-		-		-				

## BRYOZOA

Crisia denticulataCrisia sp.Bugula harmsworthiBugula sp.Mucronella pavorella (?)Membranipora sp.Schizoporella sp.

## BRACHIOPODA

Terebratulina septentrionalis  
Couthouy

## CHORDATA

Ascidacea

Molgula sp.Boltenia oviferaBostrichobranchus pilularis (Verrill)Molgula manhattensis (?)

## ANNELIDA

## POLYCHAETA

Aphroditidae

Aphrodita aculeata (Linnaeus)

Polynoidae

Harmothoe spinulosa (Verrill)Hartmania moorei PettiboneHarmothoe imbricata (Linnaeus)H. oerstedii (Malmgren)Harmothoe sp.

	1	2	3	4	5	6	7	8	9	10	10	10	10	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
<u>Crisia denticulata</u>			-					-	-												-						-	-											
<u>Crisia</u> sp.																																							
<u>Bugula harmsworthi</u>																																							
<u>Bugula</u> sp.																																							
<u>Mucronella pavorella</u> (?)																												-											
<u>Membranipora</u> sp.																																							
<u>Schizoporella</u> sp.																																							
<u>Terebratulina septentrionalis</u> Couthouy	-	-	-	-	-	-	-	-	-	-		-											-																
<u>Molgula</u> sp.			-		-																																		
<u>Boltenia ovifera</u>																																							
<u>Bostrichobranchus pilularis</u> (Verrill)																																							
<u>Molgula manhattensis</u> (?)																																							
<u>Aphrodita aculeata</u> (Linnaeus)										-										-																			
<u>Harmothoe spinulosa</u> (Verrill)			-																																				
<u>Hartmania moorei</u> Pettibone																																							
<u>Harmothoe imbricata</u> (Linnaeus)																																							
<u>H. oerstedii</u> (Malmgren)																																							
<u>Harmothoe</u> sp.			-			-				-											-																		

[illegible]

Nephtys sp. immature



## Cirratulidae (continued)

Cirratulus grandis Verrill

Cirratulid sp.

Flabelligeridae

Pherusa plumosa (Muller)Pherusa affinis (?)Pherusa sp.Brada granulosa, HansenBrada sp.Diplocirrus hirsutus (Hansen)

Scalibregmidae

Scalibregma inflatum Rathke

Opheliidae

Ammotrypane sulogaster Rathke

Maldanidae

Praxillella gracilis (Sars)P. practermissa (Malmgren)Praxillella sp.Axiiothella catenata (Malmgren)Maldane sarsi MalmgrenNicomache lumbricalis (Fabricius)

Maldanid sp.

Paraonidae

Aricidia quadralobata (Webster and Benedict)

Pectinariidae

Pectinaria hyperborea (Malmgren)P. granulata (Linne)

Aplistobranchidae

Aplistobranchus tullbergi

	1	2	3	4	5	6	7	8	9	10	10	10	10	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
<u>Cirratulus grandis</u> Verrill			-																																				
Cirratulid sp.											-		-							-		-				-	-		-	-	-								
Flabelligeridae																																							
<u>Pherusa plumosa</u> (Muller)						-						-																						-					
<u>Pherusa affinis</u> (?)																				-																			
<u>Pherusa</u> sp.					-												-							-															
<u>Brada granulosa</u> , Hansen					-																					-													
<u>Brada</u> sp.																									-														
<u>Diplocirrus hirsutus</u> (Hansen)			-							-		-	-					-		-																	-		
Scalibregmidae																																							
<u>Scalibregma inflatum</u> Rathke			-								-	-						-		-	-	-	-	-	-	-	-	-	-	-					-	-	-		
Opheliidae																																							
<u>Ammotrypane sulogaster</u> Rathke					-													-		-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Maldanidae																																							
<u>Praxillella gracilis</u> (Sars)										-	-	-	-					-					-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
<u>P. practermissa</u> (Malmgren)									-	-		-	-					-							-	-	-	-	-	-						-	-	-	
<u>Praxillella</u> sp.																				-																			
<u>Axiiothella catenata</u> (Malmgren)											-	-	-					-		-				-															
<u>Maldane sarsi</u> Malmgren	-	-						-	-	-	-	-	-	-			-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
<u>Nicomache lumbricalis</u> (Fabricius)					-			-	-											-			-	-	-	-	-												
Maldanid sp.											-																												
Paraonidae																																							
<u>Aricidia quadralobata</u> (Webster and Benedict)			-								-	-	-							-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Pectinariidae																																							
<u>Pectinaria hyperborea</u> (Malmgren)																																							
<u>P. granulata</u> (Linne)																																							
Aplistobranchidae																																							
<u>Aplistobranchus tullbergi</u>											-	-	-																										

## Ampharetidae

Melinna cristata (Sars)Ampharetidae sp.Ampharete arctica Malmgren

## Terebellidae

Pista paculata (Dalyell)Pista cristata (Müller)Thelepus cinctatus (Fabricius)Terebellides stroemi SarsPolycirrus eximius (Leidy)Amphitrite cirrata (Müller)Polycirrus sp.Streblosoma intestinalis SarsTrichobranchus glacialis Malmgren

## Sabellidae

Euchone rubrocincta (Sars)Potamilla reniformis (Leukhart)Potamilla neglectaPotamilla sp.Myxicola infundibulum (Montagu)Sabella crassicornis SarsChone infundibuliformis Krøyer

## Serpulidae

Hydroides uncinata (Philippi)Spirorbis borealis DaudinSpirorbis granulatus (Linnaeus)

## Sternaspidae

Sternaspis scutata (Ranzani)

	1	2	3	4	5	6	7	8	9	10	10	10	10	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	
<u>Melinna cristata</u> (Sars)											-		-							-	-					-								-					-	
<u>Ampharetidae</u> sp.										-							-					-	-					-												
<u>Ampharete arctica</u> Malmgren			-																		-					-											-			
<u>Pista paculata</u> (Dalyell)									-																															
<u>Pista cristata</u> (Müller)			-							-											-		-	-		-			-					-						
<u>Thelepus cinctatus</u> (Fabricius)			-		-				-	-							-										-													
<u>Terebellides stroemi</u> Sars			-								-						-		-	-			-	-		-				-										
<u>Polycirrus eximius</u> (Leidy)																																								
<u>Amphitrite cirrata</u> (Müller)																																								
<u>Polycirrus</u> sp.															-																									
<u>Streblosoma intestinalis</u> Sars																																	-							
<u>Trichobranchus glacialis</u> Malmgren																																								
<u>Euchone rubrocincta</u> (Sars)																	-	-																						
<u>Potamilla reniformis</u> (Leukhart)	-							-																			-													
<u>Potamilla neglecta</u>																																								
<u>Potamilla</u> sp.										-																														
<u>Myxicola infundibulum</u> (Montagu)																																								
<u>Sabella crassicornis</u> Sars																																								
<u>Chone infundibuliformis</u> Krøyer																																								
<u>Hydroides uncinata</u> (Philippi)			-	•••	•																						••	•												
<u>Spirorbis borealis</u> Daudin			-	•••	-				-													•	•				••	••			-									
<u>Spirorbis granulatus</u> (Linnaeus)			-																								••	•												
<u>Sternaspis scutata</u> (Ranzani)							-	-		-		-	-			•	•			•	•	•	-	•		-	-		-	•		-	-		-	-		•		

## MOLLUSCA

## PELECYPODA

*Anomia aculeata* Gmelin*Anomia simplex* Say*Arctica islandica* (Linn.)*Astarte borealis* Schum.*Astarte subequilata* Sby.*Astarte undata* Gould*Cerastoderma pinnulatum* (Conrad)*Chlamys islandicus* (Müller)*Crenella glandula* (Totten)*Hiatella arctica* (Linn.)*Macoma calcaria* Gmelin*Modiolus modiolus* (Linn.)*Musculus niger* (Gray)*Nucula delphinodonta*, Mighels & Adams*Nucula tenuis* (Montagu)*Nuculana tenuisulcata* (Couthouy)*Periploma fragile* (Totten)*Thyasira gouldi* (Phil)*Venericardia borealis* (Conrad)*Yoldia sapotilla* (Gould)

## GASTROPODA

*Alvania carinata*, Mighels & Adams*Aporrhais occidentalis* Beck*Buccinum totteni* (?)*Buccinum undatum* Linn.*Colus pygmaea* (Gould)

	1	2	3	4	5	6	7	8	9	10	10	10	10	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	
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## GASTROPODA (continued)

Cylichna alba (Brown)Epitonium greenlandicum (Perry)Lepeta caeca (Müller)Lora pleurotomaria CouthouyLora scalaris (Müller)Lora sp.Lunatia heros SayLunatia levicula VerrillLunatia sp.Margarites groenlandicus (Gmelin)Margarites umbilicus (Brod. & Sow.)Nassarius trivittatus (Say)Natica clausi Brod. & SayNeptunea decemcostata (Say)Odostomia sulcosa (Migh.)Oenopota concinnula (Verrill)Oenopota pyramidalis (Ström)Philina finmarchia SarsPuncturella noachina (Linn.)Retusa obtusa (Montagu)Trichotropis borealis Brod. & SayVelutina laevigata (Linn.)Philina lima (Brown)Tachyrhynchus erosum (Couthouy)

## APLACOPHORA

Chaetodermis

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[illegible]

Haploerys tricolor Liljeborg

CRUSTACEA (continued)

[illegible]

Corophium crassicorne (?) Brazelius

Isopod sp. A

Isopod sp. B

Isopod sp. C

Isopod sp. D

Taxid sp. A

Idotea (?) sp.

Gambusia sp.

Epelya sp.

Cancer sp. immature

Netops sp.

PHYCOCYSTIDA

Nymphon grossipes

Nymphon longitarsis

Nyxodon sp.

Phoxichilidium maxillare

**Pycnogonida sp.**

ECHINODERMATA

Ctenodiscus crispatus

Heuricia sanguinolenta

Hippasteria phrygiaca

Solaster (Crossaster) papposus

Leptasterias tenera

Asterias vulgaris

Ophiura sarcis

Ophiura robusta

ECHINODERMATA (continued)

Ophiopholis aculeata

Echinarachnoides parva

Strongylocentrotus droebachiensis

Caudina arenata

Immature Asteroidea

Immature Ophiuroides

Immature Holothuroidea

1	2	3	4	5	6	7	8	9	10	10	10	10	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	
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